US005714721A

United States Patent [19]

Gawronski et al.

[11] **Patent Number:** 5,714,721

[45] **Date of Patent:** *Feb. 3, 1998

[54] **PORTING**

[75] Inventors: **Brian J. Gawronski**, Northboro; **Gerald F. Caron**, Andover, both of Mass.

[73] Assignee: **Bose Corporation**, Framingham, Mass.

[*] Notice: The term of this patent shall not extend beyond the expiration date of Pat. No. 5,092,424.

[21] Appl. No.: **739,300**

[22] Filed: **Oct. 29, 1996**

Related U.S. Application Data

[63] Continuation of Ser. No. 843,858, Feb. 27, 1992, abandoned, which is a continuation-in-part of Ser. No. 621,531, Dec. 3, 1990, Pat. No. 5,092,424.

[51] Int. Cl.^{6} **H05K 5/00**
[52] U.S. Cl. 181/156; 181/145; 181/148; 181/199
[58] Field of Search 181/144, 145, 181/148, 156, 199, 150; 381/159

[56] **References Cited**

U.S. PATENT DOCUMENTS

2,900,040	8/1959	Novak	181/152
3,142,353	7/1964	Todisco	181/145
4,206,831	6/1980	Welch et al.	181/159
4,213,515	7/1980	Laupman	181/145
4,301,332	11/1981	Dusanoek	181/144
4,549,631	10/1985	Bose	181/156 X
4,596,305	6/1986	Jagborn	181/151
4,790,408	12/1988	Adair	181/144
4,869,340	9/1989	Coudoux	181/146
4,875,546	10/1989	Kman	181/150 X
4,964,482	10/1990	Meyer	181/146
5,067,583	11/1991	Hathaway	181/151
5,092,424	3/1992	Schreiber et al.	181/145
5,109,422	4/1992	Furukawa	381/96

OTHER PUBLICATIONS

Fluid Mechanics, Viscous Flow in Ducts, pp. 335–336, 348, 360–365, 404–411.

Lyle F. Yerges, "Sound, Noise, and Vibration Control" Sep. 1969, pp. 33–69.
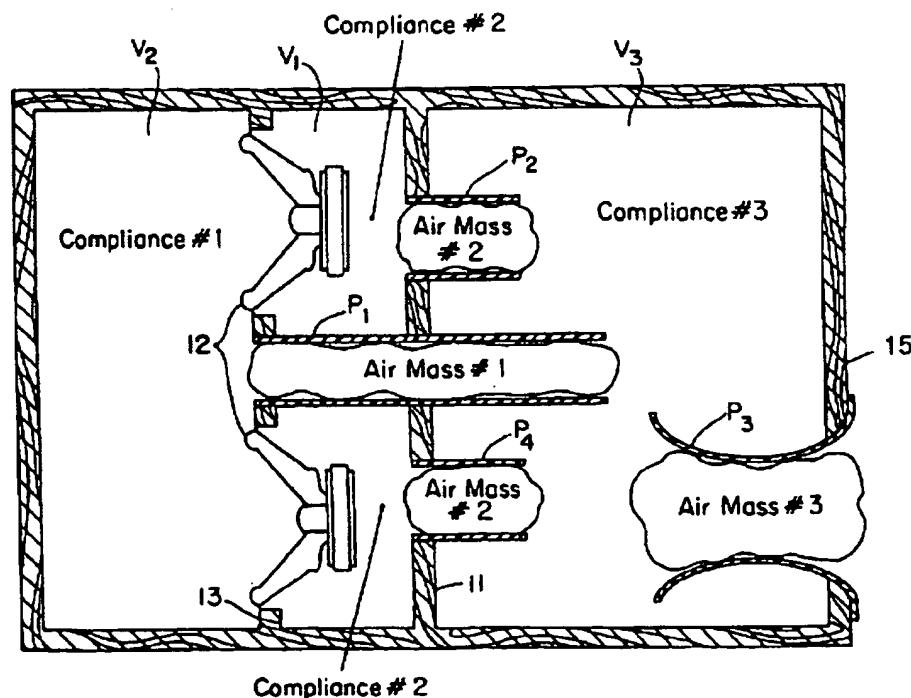
Primary Examiner—Eddie C. Lee
Attorney, Agent, or Firm—Fish & Richardson P.C.

[57] **ABSTRACT**

A loudspeaker enclosure has an inside volume. At least one port characterized by predetermined mass intercouples the inside volume and the region outside the enclosure. Each port has a smoothly flared input end within the inside volume and smoothly flared output end adjacent to the region outside the inside volume. The port defines a boundary between the acoustic mass therein and the inside volume, the boundary typically being defined by an ellipse, and in a particular form by the rotation of an ellipse about the axis of a port. Typically, the length of the port corresponds substantially to the major diameter of the ellipse.
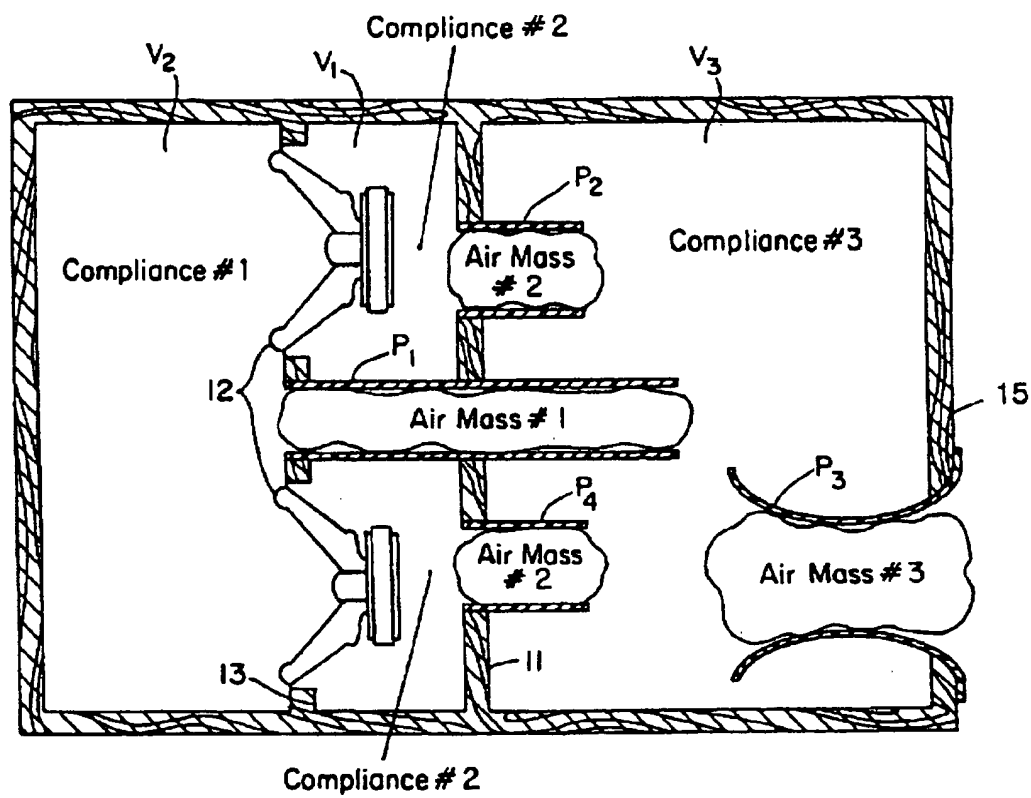
6 Claims, 2 Drawing Sheets

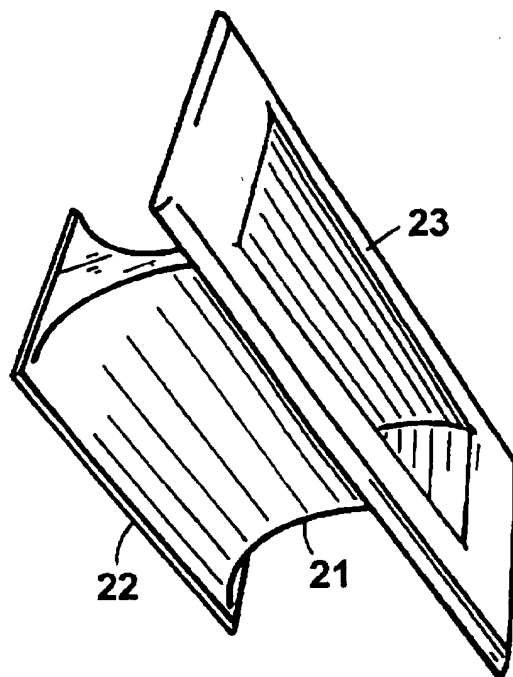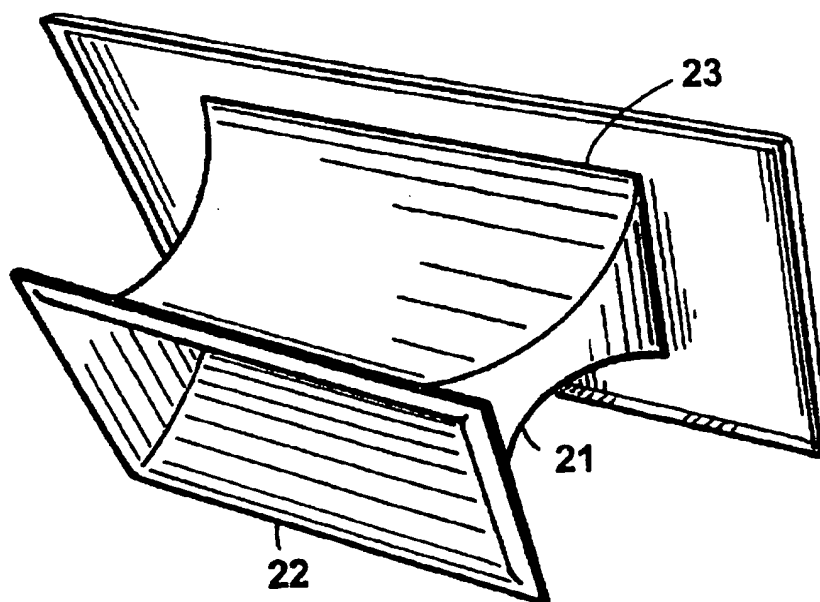**FIG. 1**

FIG. 2A

FIG. 2B

1

PORTING

This is a continuation of application Ser. No. 07/843,858, filed Feb. 27, 1992, now abandoned which is continuation-in-part application of Ser. No. 07/621,531, filed Dec. 3, 1990, now issued as U.S. Pat. No. 5,092,424.

The invention relates to porting in a loudspeaker system.

According to the invention, there is a port or tube for radiating acoustic energy to the region outside a loudspeaker enclosure smoothly flared at each end. The port has a lengthwise axis and is typically symmetrical about the lengthwise axis and smoothly flared at each end for substantially the entire perimeter about the lengthwise axis. The tube has a cross-sectional area that progressively decreases towards the center. According to one aspect of the invention, the port is bounded by an elliptical toroid, such that the tube length is approximately equal to the major diameter of an ellipse rotated about the port axis to form the toroid. An exemplary port according to the invention is embodied in the commercially available Bose Acoustimass® 5 series II loudspeaker system incorporated herein by reference. According to another aspect, the port is of rectangular cross section.

The tapered cross section of the flared port helps reduce turbulent airflow that might cause audible noise when radiating at high velocity levels.

Other features and advantages will become apparent from the following detailed description when read in connection with the accompanying drawing in which:

FIG. 1 is a cross section of a loudspeaker system including a flared port according to the invention; and

FIGS. 2A and 2B are perspective views of another embodiment of the invention of rectangular cross section exposing the smoothly flared input end and smoothly flared output end, respectively.

A loudspeaker enclosure or cabinet 11 has multiple subchambers, V_1–V_3, and multiple passive radiators, P_1–P_4, such as ports. Woofers 12 are mounted on first dividing wall 13 which separates first internal subchamber V_1 from second subchamber V_2. Second dividing wall 11 separates subchambers V_1 and V_2 from subchambers V_3 and includes three passive radiators P_1, P_2, and P_4. Flared passive radiator P_3 is mounted in external wall 15 for radiating acoustic energy to the region outside the enclosure.

The invention is embodied in the commercially available ACOUSTIMASS® 5 series II bass module being manufactured and sold by the assignee of this application. This commercial embodiment has the following representative parameters:

Volume of intermediate subchamber V_1 is 0.00413m³

Volume of end subchamber V_2 is 0.00657m³

Volume of end subchamber V_3 is 0.0119m³

Port tube passive radiator P_1 is 0.203m long by 0.044m in diameter.

Port tube passive radiators P_2 and P_4 are each 0.057m long by 0.051m in diameter.

Flared port tube passive radiator P_3 is 0.12m long by 0.12m in diameter at each end and 0.058m in diameter at the center bounded by the inside of a toroid of elliptical cross section. The ellipse has a major diameter substantially equal to the length of the tube.

2

The woofers are 14 cm diameter woofers. These parameters produce three deflection minima at 44 Hz, 80 Hz and 190 Hz and provide a frequency response characteristic having a relatively uniform response over the bass frequency range and a sharp cutoff at 30 db per octave above 200 Hz to sharply reduce the radiation of undesired harmonics through flared port P_3.

The tapered cross section of flared port tube P_3 helps reduce turbulent airflow to the region outside the enclosure that might produce audible noise when radiating at high velocity levels.

Referring to FIGS. 2A and 2B, there is shown an alternate embodiment of the invention in which the port is of rectangular cross section. Port conduit 21 has a flared inside end 22 and a flared outside end 23. Preferably, the curvature of each flared end portion is substantially the same. It may also be advantageous to have the surface of each side be defined by an ellipse having a major diameter corresponding to the length of the conduit. While this embodiment is shown as of generally rectangular cross section, it is within the principles of the invention to flare a conduit of any cross section, including a regular polygon. The particular curvature is preferably such as to enclose a volume of predetermined acoustic mass while producing inaudible noise at relatively high power levels.

It is believed to be advantageous for the port to be symmetrical about the port axis and symmetrical about a plane midway between the port ends. It is believed to be advantageous for the port cross-sectional area to be a minimum in this plane midway between the ends.

Other embodiments are within the claims.

What is claimed is:

1. A loudspeaker enclosure with at least one port for radiating acoustic energy to a region outside said enclosure and having an inside volume,

said at least one port having an axis and characterized by predetermined acoustic mass intercoupling said inside volume and the region outside said enclosure having a smoothly flared input end within said inside volume and a smoothly flared output end adjacent to the region outside said inside volume,

wherein said port defines a boundary between the acoustic mass therein and said inside volume,

said boundary being defined by an ellipse having a major diameter.

2. A loudspeaker enclosure in accordance with claim 1 wherein said boundary is defined by the rotation of said ellipse about the axis of said port.

3. A loudspeaker enclosure in accordance with claim 2 wherein the length of said port corresponds to the major diameter of said ellipse.

4. A loudspeaker enclosure in accordance with claim 1 wherein said at least one port is of circular cross section.

5. A loudspeaker enclosure in accordance with claim 1 wherein said at least one port is of rectangular cross section.

6. A loudspeaker enclosure in accordance with claim 1 wherein said at least one port is symmetrical about a plane perpendicular to said axis midway between said input end and said output end.

* * * * *

(12) **REEXAMINATION CERTIFICATE** (4709th)

United States Patent

Gawronski et al.

(10) **Number:** US 5,714,721 C1

(45) **Certificate Issued:** Jan. 7, 2003

(54) **PORTING**

(75) Inventors: **Brian J. Gawronski**, Northboro, MA (US); **Gerald F. Caron**, Andover, MA (US)

(73) Assignee: **Bose Corporation**, Framingham, MA (US)

Reexamination Request:
No. 90/006,109, Sep. 10, 2001

Reexamination Certificate for:

Patent No.:	**5,714,721**
Issued:	**Feb. 3, 1998**
Appl. No.:	**08/739,300**
Filed:	**Oct. 29, 1996**

(*) Notice: This patent is subject to a terminal disclaimer.

Related U.S. Application Data

(63) Continuation of application No. 07/843,858, filed on Feb. 27, 1992, now abandoned, which is a continuation-in-part of application No. 07/621,531, filed on Dec. 3, 1990, now Pat. No. 5,092,424.

(51) **Int. Cl.**^{7} **H05K 5/00**

(52) **U.S. Cl.** 181/156; 181/145; 181/148; 181/199

(58) **Field of Search** 181/144, 145, 181/148, 150, 156, 159, 199

(56) **References Cited**

U.S. PATENT DOCUMENTS

1,930,757	A	* 10/1933	Kirke et al.	181/199
D101,684	S	10/1936	Sweeney	
3,037,081	A	5/1962	Carlsson	179/1

3,547,221	A	12/1970	Hedberg	181/31
3,684,051	A	8/1972	Hopkins	181/31
3,688,864	A	9/1972	Guss	181/31
3,892,288	A	7/1975	Klayman et al.	181/156
4,006,311	A	2/1977	Carlsson	179/1
4,104,610	A	* 8/1978	Inoue et al.	367/93
4,158,400	A	* 6/1979	Vice	181/144
4,284,166	A	8/1981	Gale	181/156
4,324,313	A	* 4/1982	Nakagawa	181/187
4,524,845	A	6/1985	Perrigo	181/152
4,878,561	A	* 11/1989	Tengstrand et al.	181/144
4,893,695	A	* 1/1990	Tamura et al.	181/146

FOREIGN PATENT DOCUMENTS

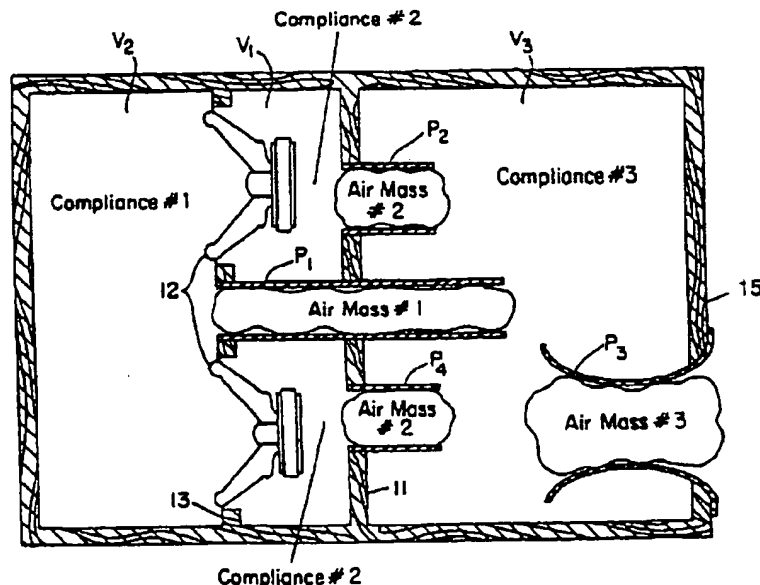|				
FR	2 623 337	5/1989	....	H01R/1/28
JP	58-121895	7/1983	....	H04R/1/02
JP	5-122785	6/1993	....	H04R/1/02

OTHER PUBLICATIONS

KEF Electronics, Ltd., Promotional brochure for KEF Speaker Model 104/2, 1985, (6 pages).
International Standard 5167, Global Engineering Documents, 1980, including pp. 1–5 and 20–26 (14 pages).

* cited by examiner

Primary Examiner—Shih-yung Hsieh

(57) **ABSTRACT**

A loudspeaker enclosure has an inside volume. At least one port characterized by predetermined mass intercouples the inside volume and the region outside the enclosure. Each port has a smoothly flared input end within the inside volume and smoothly flared output end adjacent to the region outside the inside volume. The port defines a boundary between the acoustic mass therein and the inside volume, the boundary typically being defined by an ellipse, and in a particular form by the rotation of an ellipse about the axis of a port. Typically, the length of the port corresponds substantially to the major diameter of the ellipse.

1

REEXAMINATION CERTIFICATE
ISSUED UNDER 35 U.S.C. 307

NO AMENDMENTS HAVE BEEN MADE TO
THE PATENT

2

AS A RESULT OF REEXAMINATION, IT HAS BEEN
DETERMINED THAT:

The patentability of claims 1–6 is confirmed.

* * * * *